

PACKED BED REACTOR TEST

Packed Bed Reactor Test Unit

The packed bed reactor is a fixed media system. Treatment occurs through biological activity from the organisms attached to the support media as the wastewater passes through the media.

The PBR tested at the Adams facility was an upflow system and consisted of a 9-foot section of schedule 80 PVC pipe, with a diameter of 10 inches. The PBR system was fitted with an influent pump, feed flowmeter, methanol injection system, and other appurtenances. The support media, for biological growth, were 1-inch-diameter, plastic Jaeger Tri-pack spheres with a void volume of 90 percent, a surface area of 85 square feet per cubic foot of spheres, and a weight of 6.2 pounds per cubic foot of spheres. A schematic of the PBR tested at the Adams facility is shown in Figure 63.

Packed Bed Reactor Operations - December 16, 1993 through November 21, 1995

After the PBR was inoculated with effluent from the UASBR, testing commenced on December 16, 1993 (Day 458), at a feed flow rate targeted at 0.1 gpm and a methanol dosage rate of 300 mg/L. Data collection commenced on January 1, 1994. The feed flow rate remained targeted at 0.1 gpm for the entire testing period, while the targeted methanol dosage rate was reduced to 200 mg/L on March 17, 1994 (Day 549), and then increased to 250 mg/L on August 1, 1994 (Day 549). The phosphate dosage for the influent drainage water to the Adams facility was increased to 1.3 mg/L from 0.25 mg/L on August 29, 1995 (Day 1079).

PBR operations were suspended for two prolonged periods from March 10, 1995 (Day 907) through March 30, 1995 (Day 927) due to flooding of the site and from August 30, 1995 (Day 1080) through September 15, 1995 (Day 1096) for maintenance activities. Problems were encountered in maintaining consistent influent flow and methanol dosage rates into and through the PBR throughout the testing period. On February 21, 1994 (Day 525), the influent flow rate, measured by graduated cylinder and stopwatch, was determined to be 0.02 gpm.

The flow problems were related to buildup of gas, biological growth, and precipitation of salt inside the PBR, the influent lines, and the effluent lines. Modifications made to resolve the flow problems included replacing a pressure regulating valve on the discharge line of the dosing pump on February 21, 1994 (Day 525); installing a gas relief valve on top of the PBR in March 1994; relocating the PBR's control valve and flow meter to the influent line from the effluent line on April 1, 1994 (Day 564), and October 10, 1994 (Day 756), respectively; and separating the PBR's feed line from the line that also fed the UA2 and FBR2 on September 22, 1995 (Day 1103). Regular maintenance activities were instituted to flush the influent and effluent lines of biological growth, gas, and precipitated salt as well as to clean the PBR and distribution plate to remove biological growth and precipitated salt.

Packed Bed Reactor Results

The PBR was operated as a single-stage reactor, ran parallel to the UASBR and FBR2, and reduced both selenium and nitrate. The feed selenium concentrations were previously presented

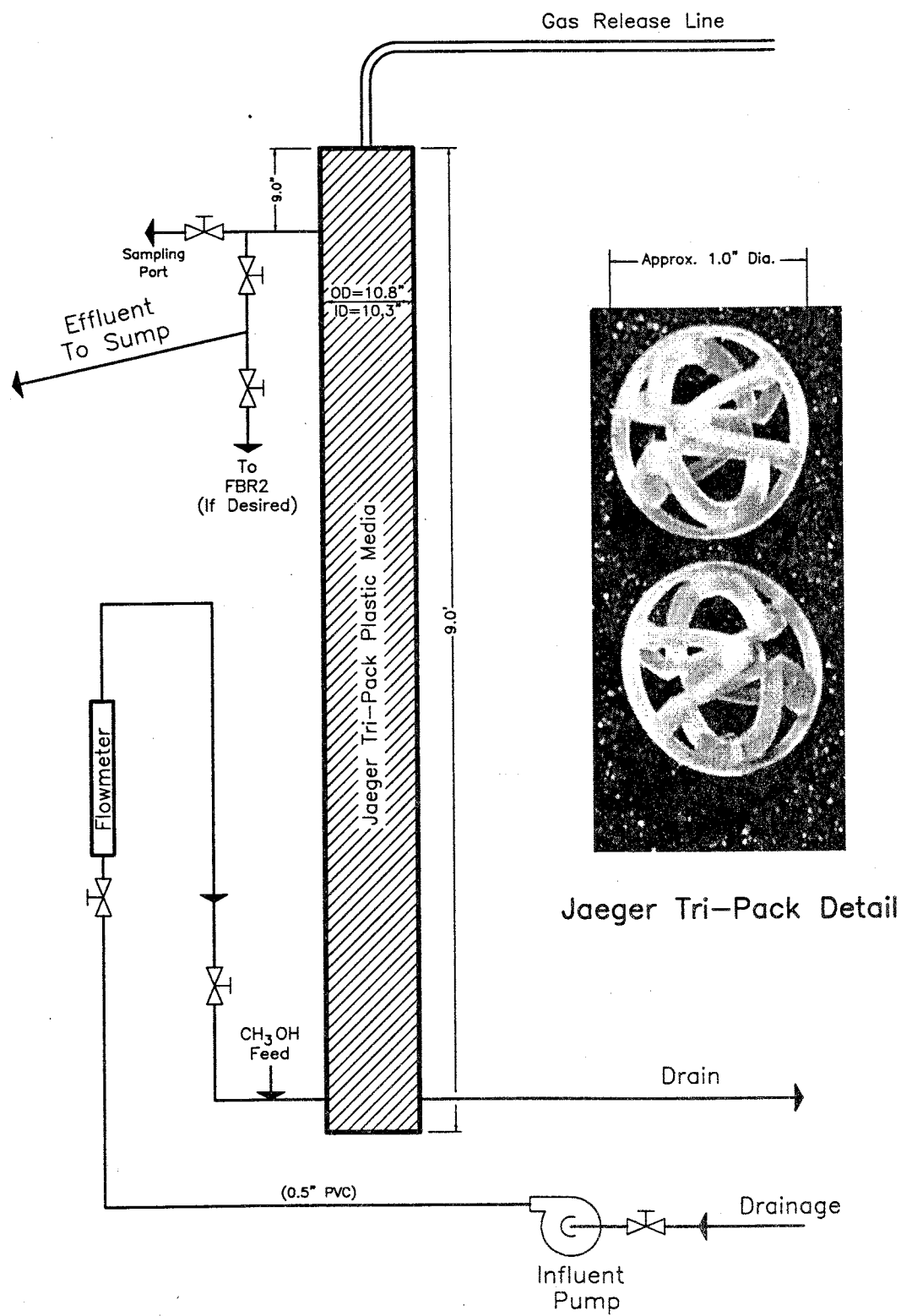


Figure 63. Packed Bed Reactor Schematic

in the UASBR Period 3 section, Figure 13. The average influent Tse, Sse, and selenite concentrations for the entire PBR operation period from January 1, 1994 through November 21, 1995 were 524 ug/L, 506 ug/L and 3 ug/L, respectively. Figure 64 shows the effluent concentrations for Tse, Sse, and selenite and averaged 387 ug/L, 243 ug/L, and 30 ug/L, respectively, for the entire 23-month operation period.

Figure 65 shows the percentages of Tse and Sse reduced and dates when targeted methanol dosage rates were changed. The reduction percentages fluctuated throughout the testing period and averaged 26% and 51% for Tse and Sse, respectively.

Influent and effluent nitrate concentrations are shown by Figure 66. The effluent concentration fluctuated during the course of operations and at times was greater than that of the influent. The influent and effluent concentrations for the operation period averaged 29 mg/L and 11 mg/L, respectively.

The ambient and reactor temperatures are shown by Figure 67. The reactor temperature basically followed the ambient temperature. The average ambient from reactor temperature difference was 1.6 C.

Figure 68 shows influent and effluent dissolved oxygen. Effluent DO from the PBR remained stable throughout the entire testing period and averaged 0.8 mg/L. The influent averaged 8.8 mg/L.

Methanol dosage and the two dates for when the target rate was changed are shown by Figure 69. Even though a stable dosage rate was difficult to maintain, the average dosage rate for the three periods were 321 mg/L, 218 mg/L, and 269 mg/L for target rates of 300 mg/L, 200 mg/L, and 250 mg/L, respectively.

Influent and effluent total organic carbon concentrations are shown by Figure 70. Aside from a period at the beginning of operations, the effluent TOC concentrations remained relatively stable and averaged 32 mg/L (without the beginning period previous to February 21, 1994), while the influent averaged 13 mg/L for the same period.

Figures 71, 72, and 73 show influent and effluent total suspended solids, volatile suspended solids, and total dissolved solids, respectively. Even though the influent and effluent TSS concentrations varied throughout the operation period, they both averaged 19 mg/L. The influent and effluent VSS concentrations also fluctuated throughout the entire operation period, but averaged 5 mg/L and 8 mg/L, respectively. The effluent TDS concentration was consistently less than the influent and averaged 6,710 mg/L, while the influent averaged 8,200 mg/L for the period.

Influent and effluent alkalinity and electrical conductivity are shown by Figures 74 and 75. Influent alkalinity was always lower than the effluent, and the difference between the two

Figure 64
PBR - Effluent Total Selenium,
Soluble Selenium and Selenite

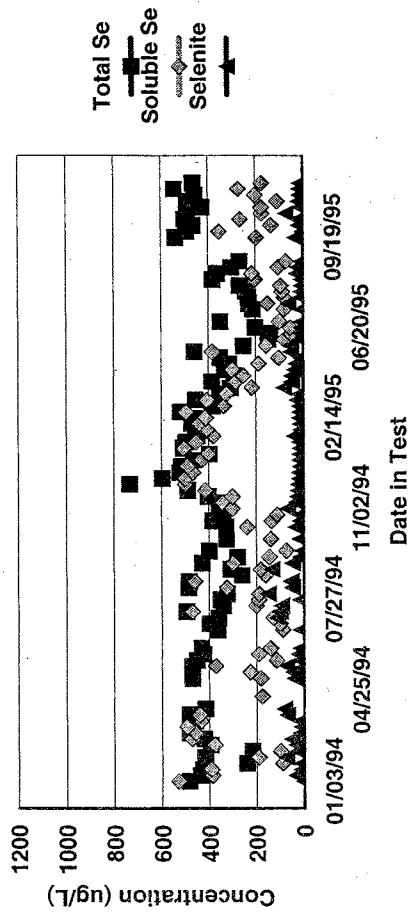


Figure 65
PBR - Percentage of Total & Soluble Selenium Reduced
and Dates for Methanol Dosage Change

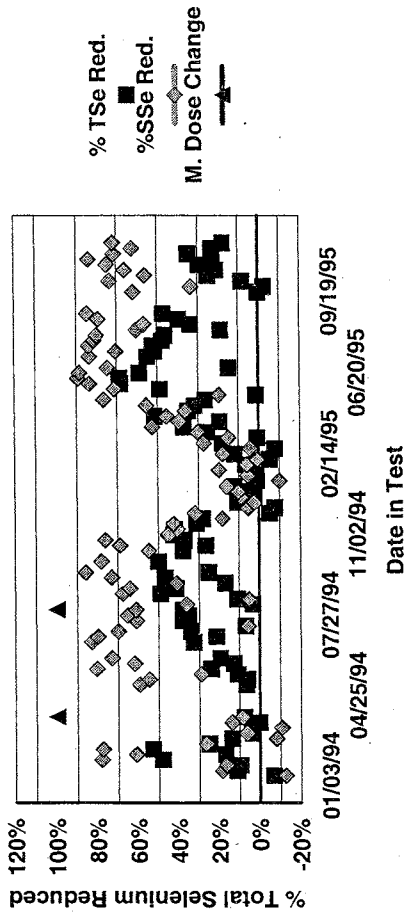


Figure 66
PBR - Influent and Effluent
Nitrate

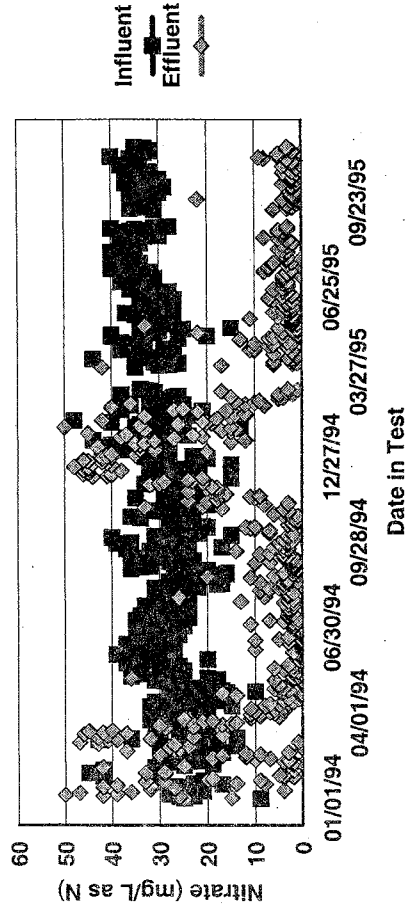


Figure 67
Reactor and Ambient Temperatures

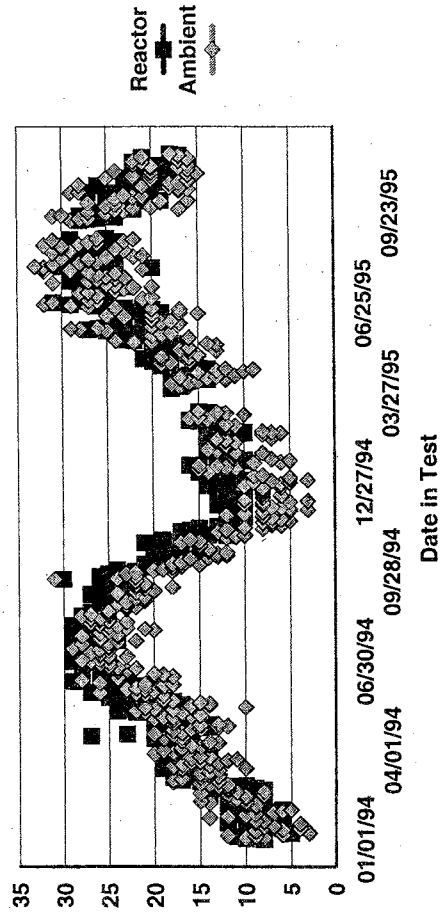


Figure 68
PBR - Influent and Effluent
Dissolved Oxygen

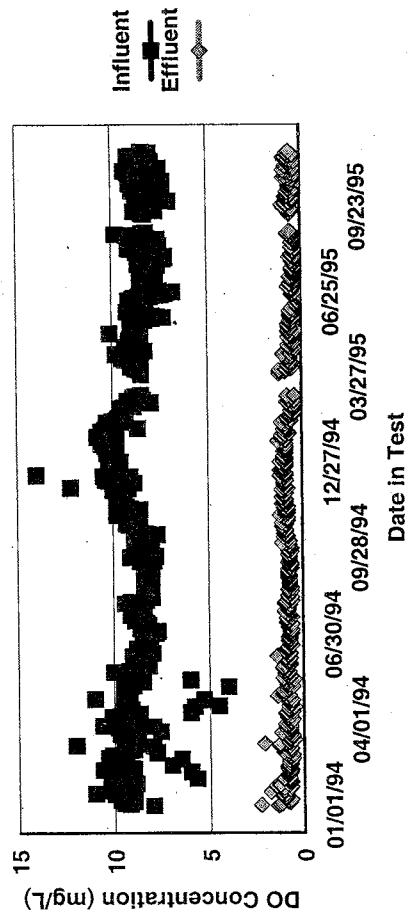


Figure 69
PBR - Methanol Dosage and Date
for Change of Target Dosage Rate

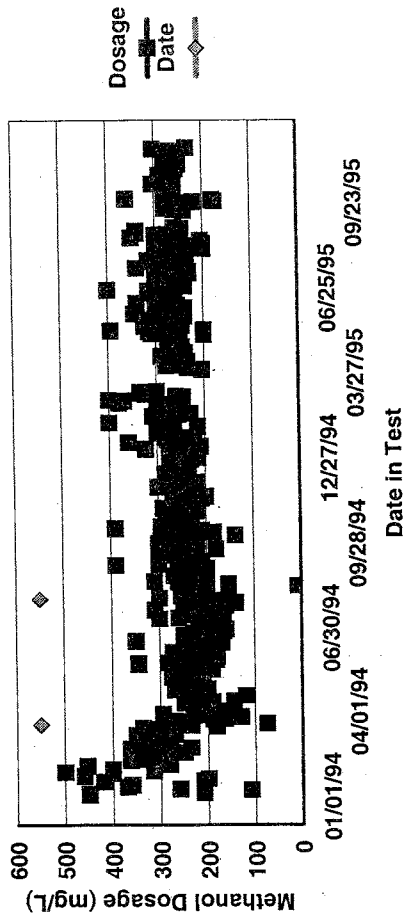


Figure 70
PBR - Influent and Effluent
Total Organic Carbon

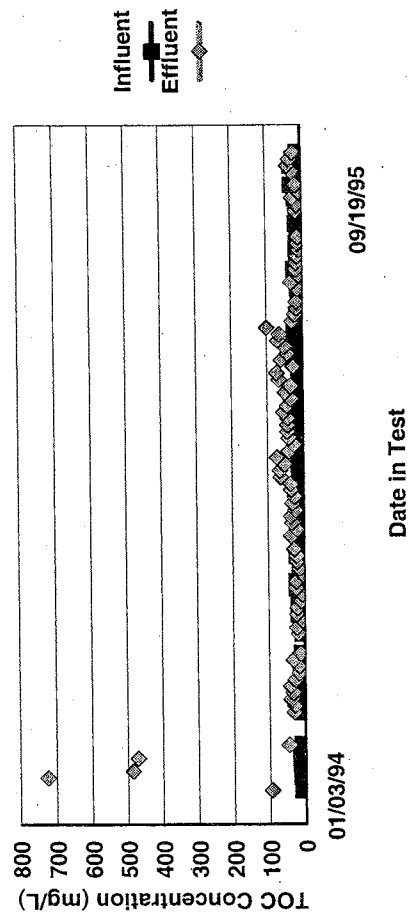


Figure 71
PRB - Influent and Effluent
Total Suspended Solids

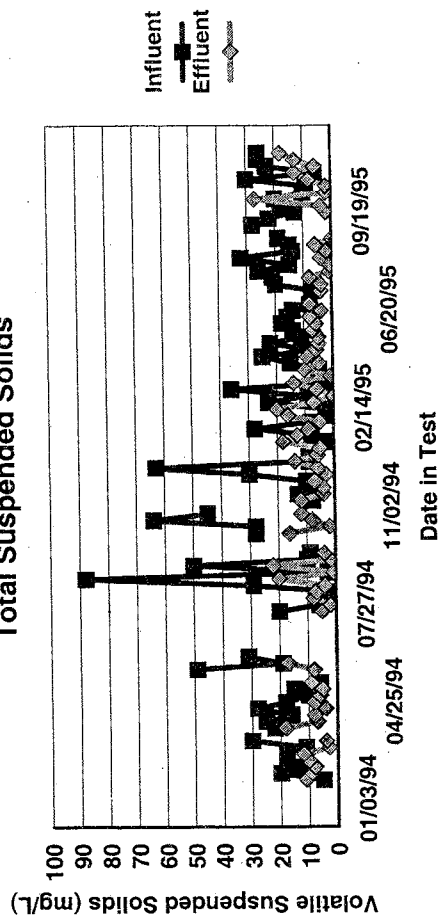


Figure 72
PBR - Influent and Effluent
Volatile Suspended Solids

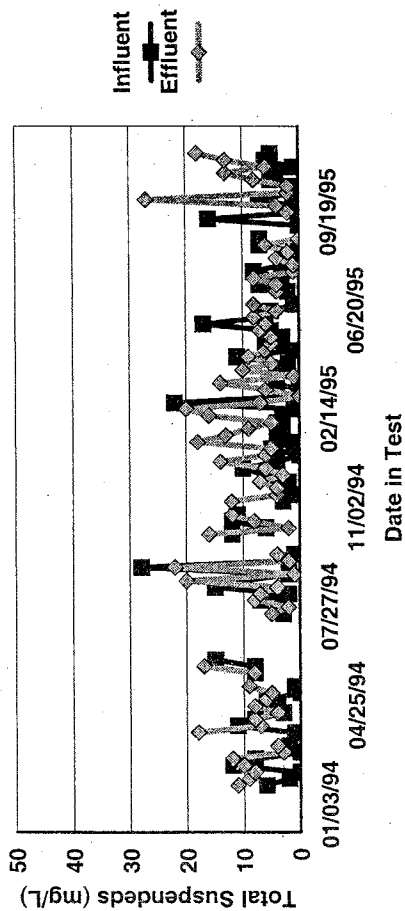


Figure 73
PBR - Influent and Effluent
Total Dissolved Solids

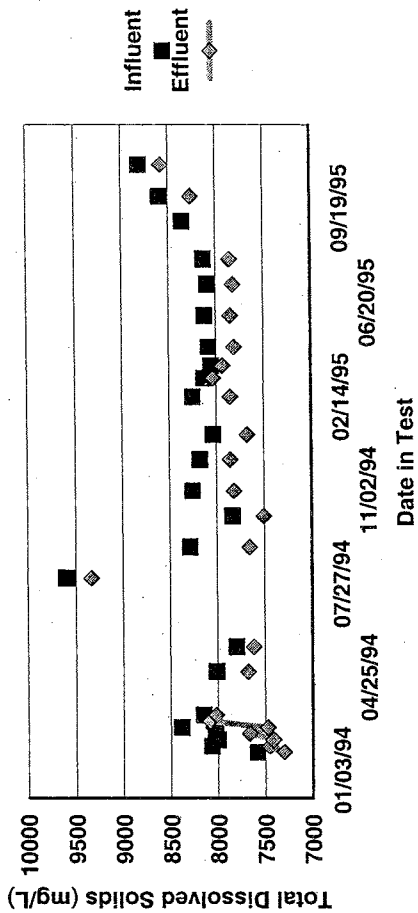


Figure 74
PBR
Influent and Effluent Alkalinity

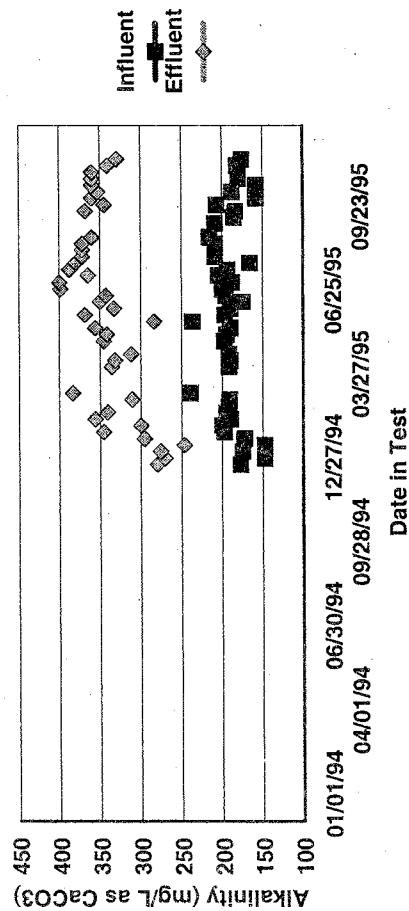
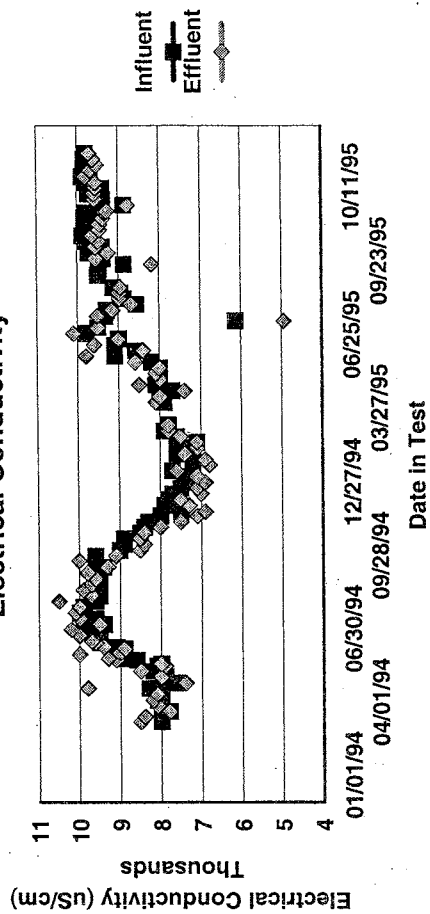


Figure 75
PBR - Influent and Effluent
Electrical Conductivity



averaged 15.3 mg/L as CaCO_3 for the entire operation period. The EC remained relatively constant between the influent and effluent values and the difference between the two, effluent from the influent, averaged 22 uS/cm.